1949

Determinants of the extent and type of cattle feeding in Iowa

George G. Judge
Iowa State College

DETERMINANTS OF THE EXTENT AND TYPE

OF CATTLE FEEDING IN IOWA

by

George Garrett Judge

A Thesis Submitted to the

Graduate Faculty in Partial Fulfillment of

The Requirements for the Degree of

MASTER OF SCIENCE

Major Subject: Agricultural Economics

Signatures have been redacted for privacy

Iowa State College

1949

TABLE OF CONTENTS

	Page
INTRODUCTION	1
The Setting	1
Objectives and Purpose of the Study	6
Historical Background	8
THEORETICAL FRAMEWORK FOR THE STUDY	12
Feeder Cattle Market	12
Model of Behavior Patterns in the Market	13
Assumptions and Definitions	14
Theory of Cattle Feeding Firm and Feeder Demand	15
Theory of firm under static conditions	15
Factor to product	21
Factor to factor	22
Product to product	25
Theory of the firm in a dynamic setting	27
Slaughter Demand in Feeder Cattle Market	33
Theory of the Supply of Feeder Cattle	35
ESTIMATION METHODS OF THE DEMAND FOR FEEDER CATTLE	41
Survey of the Simultaneous Equation Method of Statistical Analysis	42
Simultaneous equation vs. single equation	45
Further Considerations in Future Model Construction	47
Theoretical model proposed and carried through	49
Theoretical model of the demand of feeder cattle	50
Supply of feeder cattle by entrepreneurs	53
The Limited Information Statistical Analysis	55
Comparison of results with theory	58
The "Just Identified" Instrumental Variable Analysis	61
Single Equation Statistical Analysis	65
SUMMARY AND CONCLUSIONS	68
LITERATURE CITED	72
ACKNOWLEDGMENT	74

INTRODUCTION

Cattle fattening affects both the quantity and quality of the beef supply. By fattening thin cattle of desirable feeder grade, the weight of the animal is increased, the dressing percentage is increased, the quality is improved and the food nutrient content of the carcass is increased. Moreover the supply of beef can be distributed more evenly over the year and rough feeds which have no higher alternative use can be turned into food. Fattening cattle is an integral part of farming on many corn belt farms and in scattered areas in other parts of the United States. The particular characteristics, development and organization of the factors of production of many farms in these areas, result in a type of agriculture which includes cattle feeding or fattening as an integral part of a well rounded and efficiently operated farm unit. The cattle feeder essentially converts such inputs as land, labor, capital, thin cattle and feeds, into food for humans and into a large number of other useful products. The cattle feeder's main purpose is to get the largest possible net returns from feeding cattle with the amount of feed, capital and labor that he has available.

The Setting

The sale of finished cattle constitutes an important source of income to farmers in Iowa. Iowa's reputation as a leader in corn and hog production usually overshadows its role as a beef producer, yet Iowa farmers each year market more beef than the combined total sold from the six range states of Idaho, Wyoming, Colorado, New Mexico, Utah and Nevada.

There were approximately 4,722,000 cattle and calves on Iowa farms, January 1, 1948, including 770,000 beef steers on feed.[1] In 1948 Iowa farmers marketed approximately 2,334,000 head of cattle and calves, receiving a total of over 503 million dollars.[2] Since 1940 beef production in Iowa has averaged more than 800,000 tons per year live weight. Based on 1946 meat consumption per capita this output of beef amounts to a full year's supply for over 12½ million people.[3] A large share of Iowa's beef comes from dairy herds, but still more of it comes from feed lot cattle.

In the nation Iowa ranks first in the number and total value of livestock marketed annually and is second only to Texas in the number on farms. In recent years more than 20 per cent of the cash income of Iowa farmers has been derived from the sale of cattle and calves (including veal calves and cullings from dairy herds). Of this 20 per cent it is a reasonable estimate that 70 per cent is due to the sale of fattened beef. The cash income from the sale of cattle and calves in Iowa is only exceeded by the cash income from the sale of hogs.

---

[1] U.S. Bureau of Agricultural Economics. "Meat Animals, Farm Production and Income, 1947-48," pp. B.

[2] Ibid., p. 3.

[3] In 1946 the per capita consumption of beef amounted to 62.4 lbs.

There are marked variations in the number of feeder cattle marketed each year and number of feeder cattle purchased. There were variations in numbers of all cattle marketed from Iowa in the period 1935 to 1945 from 1,706,000 to 2,780,000.[1] In the same period the number of cattle imported into the state varied from 510,681 to 1,112,085.[2]

Iowa cattle feeders have handled about 1,600,000 head of beef cattle per year since 1942. On the average about 1,100,000 of these were brought in from other states to be grain finished and the remainder came from Iowa beef herds. The range states that constitute the bulk of the supply of feeder cattle imported include: North Dakota, South Dakota, Nebraska, Kansas, Oklahoma and Texas. The remainder of feeder cattle that are fed in Iowa come from other farmers who have beef herds in Iowa or are raised on farms where they are fed out. This number of feeder cattle imported into Iowa constitutes about 40 per cent of the feeder cattle imported into the eight corn belt states and even more than the next two principal importing states.[3]

The most important marketing agency involved in the movements of stocker and feeder cattle into Iowa is the terminal public market. The terminal market is decreasing in importance but it still handles about 70 per cent of the total importations. Direct buying is next in importance and has been increasing in the last few years. The remainder

---

[1] U.S. Bureau of Agricultural Economics. "Meat Animals, Farm Products and Income", 1924-45, pp. 24.

[2] Iowa Department of Agriculture, "Iowa Agriculture-Livestock, Poultry and Dairy". Bulletin 92.4. p. 14-16. 1945.

[3] Other corn belt states are Ohio, Nebraska, Michigan, Wisconsin, Illinois, Minnesota, and Indiana.

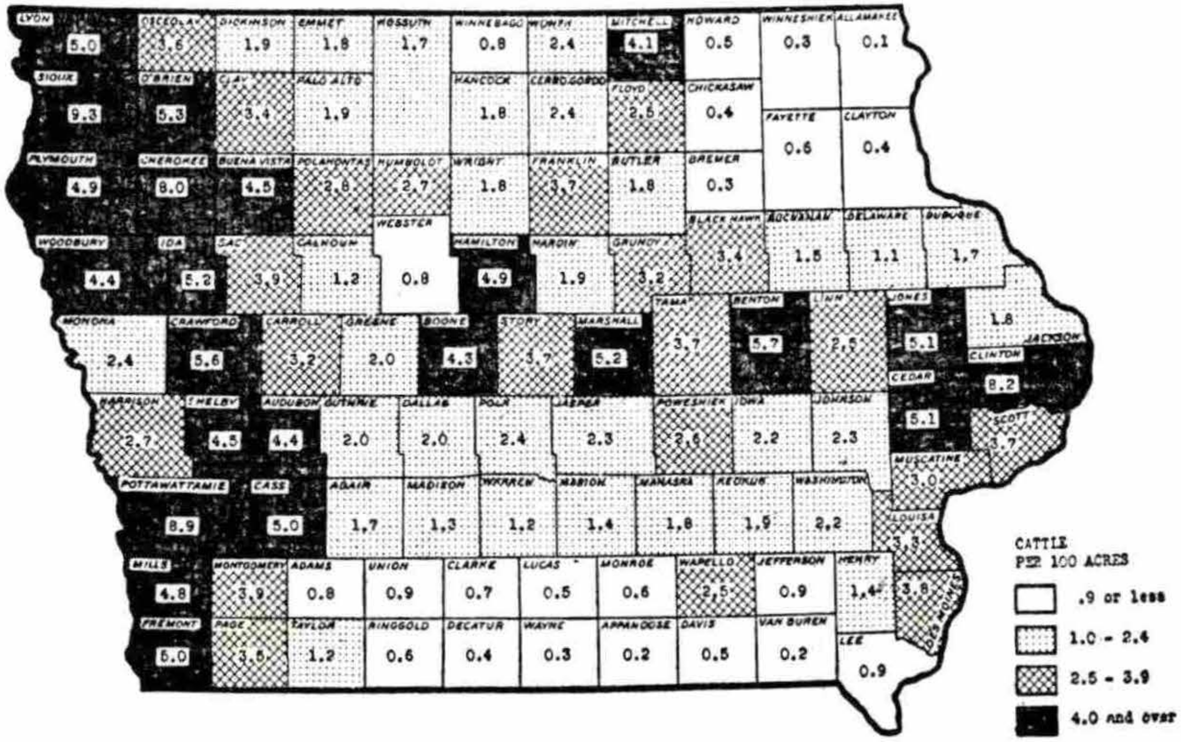
of importations are handled by private dealers and farmers buying from local auctions. About 70 per cent of the total annual inshipments are received during the months, August, September, October and November.

Cattle feeding in Iowa converts into human food a large tonnage of fodder, grass, hay and silage that might otherwise be wasted. Not only does it form a way to market these products but it furnishes a profitable employment for labor when not demanded by other enterprises and helps to maintain soil fertility by the production of manure. The feed lot also acts as a dam to hold back the flood of grass cattle coming offthe ranges in the fall. This reservoir of beef created helps to assure a steady supply of beef to the market throughout the year.

Cattle feeding of one type or the other is carried on in every county of the state. The largest area of intensive beef cattle production is in Western Iowa, centering in the second tier of counties away from the Missouri river. Another area not so nearly compact is located in East Central Iowa. The map on the following page shows the distribution of cattle fed throughout the state, in 1946. The map was taken from the U.S.D.A., B.A.E. "The Agricultural Situation", November 1947 issue.

Feeding programs and practices in Iowa should and do vary widely. There is a wide choice in grade, weight and kind of cattle available for feeding. Since there are equally wide variations in cattle feeder conditions, it is safe to say that at proper price differentials there is a satisfactory place for every sort of feeder cattle available. These feeding systems vary all of the way from putting a short term

CATTLE FEEDING IN IOWA



Source: U.S. Bureau of Agricultural Economics, "The Agricultural Situation." November 1947.

dry lot grain finish on heavy cattle to running calves through a combined grain and forage feeding period that may exceed 12 months. There is a great amount of flexibility built into the Iowa cattle feeders firm both from a standpoint of number of cattle fed, type of cattle fed, and the feeding practice carried on. The bulk of the cattle feeding is done by individual farmers who handle from 10-150 head each year.

Feeder cattle as used in this study will refer to cattle and calves received in the state for feeding and grazing. They include animals of different ages ranging from calves to older cattle. They also comprise cattle with a wide range of finish. Most of the animals are of beef finish but some are produced from dairy herds.

Objectives and Purpose of the Study

For cattle fattening to make the maximum contribution to the food supply, both when feed is plentiful and when feed is scarce and to enable public agencies and entrepreneurs of cattle feeding firms to appraise fully and accurately the economic forces which affect the supply and demand for feeder cattle, a method of evaluating these economic and physical forces must be attempted. Therefore, the main objective of this study will be to evaluate those factors which have the paramount influence on the fluctuations in the supply and demand for feeder cattle, with special reference to the number of feeder cattle imported annually for feeding.

Some knowledge of the nature of the mutual interdependence between these relevant factors in this segment of the economy is obviously a prerequisite for intelligent formulation of government policy and resource allocation of the firm or entrepreneur.

The purpose in building econometric models is to describe the way in which the system usually operates. It is the desire to discover the best possible theory or theories which explain the fluctuations that are observed. If the quantitative characteristics of the economic systems are known then it is possible to forecast with a specified level of probability the course of certain economic magnitudes such as prices of factors and products and also be able to forecast with specified probability the effect upon the system of various economic policies.

In the course of search for models which are suitable for the purpose of forecasting and policy making recommendations several alternative economic theories and admissable hypotheses will inevitably have to be considered. The acceptance or rejection of the hypotheses in the course of the search for truth will be the primary contribution to the problem of testing feeder cattle demand and supply theories. This is an important problem for which contributions are needed because too often bold statements about the operation of the system are made without examining factual data to determine whether or not the statements are true.

To the best of the knowledge of the writer no comprehensive studies have been made on this subject, and the writer realizes fully the limitations to which this study may be subject. It is hoped that this study may act as a pilot study for future work on this problem and that the statistical techniques employed may be found worthy of further extension.

Historical Background[1]

The following study attempts to trace the development of the production of beef cattle in Iowa. The beef enterprise is one which has been present in Iowa since the state was first settled. Since that time it has undergone a marked change, the greater part of which may be attributed to economic conditions.

The cattle industry in Iowa was first one of producing cattle on pasture and there was but little feeding of corn. Finishing with corn was forced to wait a few years until corn began to be grown in sufficient quantities to be used in this way. There was a growing market for grain fed cattle in the latter part of the 19th century because of increase in population and concentration of people in cities which stimulated interest in cattle feeding in Iowa.

As early as 1851 some cattle were being fed in Henry County, Iowa, by feeding corn in the fodder. A few years later husking the corn in the field was adopted and snapped corn replaced the corn and fodder mixture.

---

[1]For historical sketches on production of beef cattle see:

Hopkins, J.A., Jr. "Economic History of the Production of Beef Cattle in Iowa", Iowa City, Iowa - State Historical Society of Iowa. 1928.

Hopkins, J.A., Jr. "A Statistical Study of the Prices and Production of Beef Cattle." Iowa Agricultural Experiment Station Research Bulletin 101, Ames, Iowa, Dec. 1926.

U.S. Department of Agriculture. "Some Essentials in Beef Production", Bulletin No. 71, pp. 20. 1943.

From 1870 to the end of the century the production of corn increased rapidly and its price was generally low which favored feeding it to cattle. Freight rates for corn were high (1/5 of value) and only about .25¢ per head for cattle which favored feeding cattle because of difference in intrinsic value.

Steers were kept to the age of 3 or 4 years before being fattened. The practice was to feed on grass until 3 or 4 years old and then feed corn heavily for several months. Cattle were usually fed to weights of 1300-1400 lbs. and 1600 lbs. was not unusual.

In the nineties the possibility of raising cattle on cheap prairie grass came to an end. Land began to have higher values and it was no longer profitable to keep steers until they were 3 or 4 years old. The principal changes from 1895-1910 were in finishing of cattle at younger age and use of better roughages. Racks were now used to feed roughages and use of bunks to feed corn became almost universal. The most radical innovation in methods was the production of baby beef, i.e., taking calves from good breeding stock and starting them on grain as soon as they would take it and selling them when about 2 years old. The production of baby beef was a specialized business but usually was conducted on a rather small scale.

The methods of managing and feeding cattle in Iowa underwent continuous and logical development. The methods existing at any one time were such as the cattle producers of that time found to be most economical, taking into consideration form and costs of productive factors available.

The largest number of feeder cattle was brought in from August to November, when the greatest numbers from ranges were coming to market. The length of feeding period varied from 2 to 8 months as extreme limits.

The only available material on the volume of production of beef in Iowa prior to the time when the Department of Agriculture began to collect such data in 1919 is that published in Iowa year book of agriculture for 1909 and 1910. These reports claim that there were 301,896 head of cattle shipped into the state in 1910 and 1,153,805 shipped out in 1910. In 1926 there were 577,426 feeders shipped in and 1,899,275 shipped out. These data for imports are very inaccurate and one might say nothing more than just estimates of the numbers.

Concerning the approximate rate of increase or decrease in demand for feeder cattle something may be obtained from the reports of the agricultural societies from year to year. But these are merely a reflection of price relationships of the times, size of crops available for feeding and general business outlook.

From 1900-1908 range supply was falling off because of settlement. There was much talk concerning the necessity of producing the feeders in Iowa instead of buying them from the range. The greater part of feeder cattle during this period were grown in Iowa and were fed on the farm where grown, or were sold to neighbors to feed. Of the cattle shipped into the state by far the greatest number came from the western ranges. The principal markets where feeder cattle were obtained were Kansas City, Omaha, St. Joseph and Sioux City.

Some large feeders went direct to the western ranges and the volume of this direct business for Iowa would be very hard to estimate prior to 1934. There was a growing volume in the twenties and reports of permits granted for importing feeders was made by the state veterinarian. In 1934 issuance of such reports was made on a more adequate basis and it is not until this date that the reports can be counted as accurate.

Thus Iowa has developed from a very small producer of finished beef to now be ranked as the most important producer of finished beef. Iowa has also risen from a very small importer of feeder cattle to a position which far exceeds any other states.

THEORETICAL FRAMEWORK FOR THE STUDY

It is the specific purpose of this chapter to analyze deductively the relevant variables that determine the demand for feeder cattle by the cattle feeders in Iowa and also to determine in what way these economic and physical forces affected the quantity purchased by the cattle feeder.

Feeder Cattle Market

In the use of macrodynamic models in explaining the demand for feeder cattle, one has to consider also the economic relations which govern the other sectors of the economy.[1] The demand and supply of feeder cattle are closely interrelated and both must be analyzed in order to get a valid description of the parameters which influence the demand for feeder cattle. The demand for feeder cattle breaks down into two categories, i.e., demand by cattle feeders and demand by slaughter buyers. Because of the great number of feeder cattle, which under certain conditions, may either go to the cattle feeding lot or to the slaughter house, the slaughter buyer often competes directly with the cattle feeder for this portion of the feeder cattle.

---

[1] M.A. Girschick and Trygve Haavelmo, "Statistical Analysis of the Demand for Food Examples of Simultaneous Estimation of Structural Equations." Econometrica, Journal of Economictric Society, Vol. 15. pp. 87. 1947.

Model of Behavior Patterns in the Market

In order to evaluate the relevant parameters which affect the demand for feeders, it is necessary to set up models of behavior patterns in the market for the demand by cattle feeders and slaughter buyers and suppliers of feeder cattle. Since both buyers and sellers are firms it is necessary to set up a theory for the behavior of cattle feeders, slaughter buyers and suppliers of feeder cattle within the framework of the theory of the firm.

This will be done by analyzing deductively the production and income effects on the demand for feeder cattle by the firm. Anticipated income from alternative lines of production guides the allocation of resources and hence the production pattern. In turn the production pattern - to the extent that it influences prices of productive agents and distribution of ownership - influences the magnitudes of individual incomes. In order to simplify the analysis, income and production are usually separated.

A deductive analysis of effects of production on demand for feeder cattle is merely a special application of the theory of the firm. The production effects of the demand for feeder cattle will be treated in terms of the way in which changes in anticipated returns from production, cost of productive agents and production techniques might be expected to influence the firm's decision as to what to produce, how much to produce, and what productive agents to utilize. A brief sketch of the general outlines of the theory of the firm will be attempted so that the analysis of effects of demand for feeder cattle may be fitted into the framework of the outline.

Assumptions and Definitions

It is now in order to define a firm and make the necessary restrictive and expository assumptions for the theory of the cattle feeder market that is to follow. Validity of assumptions on which the models are based and correctness of model as a whole will be tested later with the statistical evidence available. Later the assumptions will be dropped and the effects of these changes will be discussed.

The firm may be defined as the business and planning unit in production.[1] The firm is the control unit and the plant is the production unit, but usually the relationship between the two is a 1 to 1 ratio and they can be thought of as combining to form an enterprise. Within its framework decisions are made as to the kinds and volumes of outputs, the kinds and volumes of inputs and methods of production (including disposal of products and acquisition of productive agents to be employed). These decisions are reached in light of achieving some specific object or objectives. The first assumption is that the objective of the firm is maximization of net profit. The behavior of the firm can also be analyzed if it is assumed that a combination of net profit liquidity, prestige or any other objective is to be maximized.

---

[1]For a few of many definitions of a firm refer to K.E. Boulding, "Economic Analysis", Harper and Brothers, New York, 1948. pp. 421.

T.W. Schultz - "The Theory of Firm and Farm Management Research", Journal of Farm Economics, Vol. 21. pp. 570-586. 1939.

The other assumption that will be made is that of perfect competition, i.e., perfect knowledge, infinite liquidity, and perfect mobility and divisibility of resources. This in force removes all uncertainty, risk and capital rationing that may interfere with the decision making of the entrepreneur.

Theory of Cattle Feeding Firm and Feeder Demand[1]

Having made the necessary assumptions and definitions a theory will now be constructed for the behavior of a cattle feeding firm with regard to its effects on the number of feeder cattle demanded.

The demand for feeder cattle, like the demand for the inputs of any firm, is in essence a derived demand, i.e., derived from consumer demand for fresh beef and by-products of slaughter cattle. The firm thus buys things (factors), transforms them in some way and then sells them with the purpose of making a profit.

Theory of firm under static conditions

A theory of the cattle feeding firm under static conditions will be considered first. Assuming that the prices of outputs, prices of productive agents and various production functions are not changing over

---

[1]The theory of firm also known as theory of production. For a few of many discussions of the theory of firm refer to:

J.R. Hicks, "Value and Capital" Oxford, The Clarendon Press, 1939.

F.H. Knight, "Risk, Uncertainty and Profit", Houghton Mifflin Company, 1921.

N. Kaldor, "The Equilibrium of the Firm", Economic Journal Vol. 44, pp. 60-67. 1934.

J.L. Mosak, "Interrelations of Production Price and Derived Demand". Journal of Political Economy. Vol. 46. pp. 761-87. 1938.

time what is the expected behavior of the firm - if it is attempting to maximize net profits.

Under the assumption of perfect competition that was made, the production functions, the prices of products and prices of productive agents are given. The cattle feeding firm as stated buys productive agents such as feeder cattle and corn and sells products such as finished cattle and hogs. The production function is the transformation of factors of production into products. It is assumed that the firm chooses that transformation function which will result in a maximum of product and also a maximum of profit from any given combination of productive agents. The firm's net profit will be maximized if it employs productive agents to the point where marginal returns from any factor are equivalent to its marginal cost. As will be demonstrated later, as the price of a factor, say feeder cattle is decreased relative to the prices of other factors, greater relative quantities of this factor will be used in the firm's production. Likewise, as the price of a product, say finished beef cattle, is increased relative to the price of other products, the firm will produce greater relative amounts of this product. The inverse effects will follow from price changes just the opposite from those mentioned. Thus it is shown that the price mechanism by assumption, is a means of shifting resources from one line of production to the other.

Expressed symbolically the theory of production is as follows. Let us first consider a somewhat simplified situation where farmers residing in areas of large grain production (e.g. Iowa) purchase feeder cattle and finish them for slaughter market. For the purpose of this study cattle feeding firms may be conveniently considered as having the following inputs and outputs (at their command). The quantity of hogs available to the farmer is considered unlimited and not considered as a factor of production.

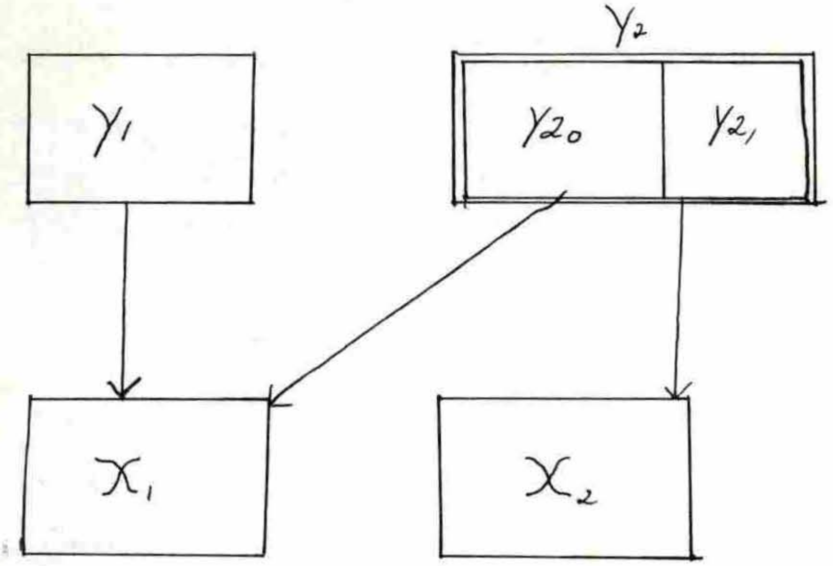


Figure 1. Model of cattle feeding firm.

Where y_1 = quantity of feeder cattle

y_2 = total supply of corn

y_{2_0} = quantity corn fed feeder cattle

y_{2_1} = quantity corn fed hogs

x_1 = quantity of finished cattle

x_2 = quantity of finished hogs

y_1, y_2 are productive agents or inputs

x_1, x_2 are products or outputs

The transformation function is expressed:

$$f(y_1, y_2, x_1, x_2) = 0$$

If the quantity of finished cattle or feeder cattle is altered then there is also a corresponding alteration in inputs of the other factor corn or output of other product hogs.

One can then solve for the relationship between the output of a product and the input of factors, yielding the production function.

$$x_1 = f(y_1, y_{2_0})$$
$$x_2 - f(y_{2_1})$$

where $y_{2_0} + y_{2_1} = y_2$

The marginal rate of transformation will be: $\frac{\partial x_1}{\partial y_{2_0}}$ This may be expressed as ratio between factors, between products or between factor and a product.

The partial derivative of the product with respect to any factor is the marginal productivity, e.g., $\frac{\partial x_1}{\partial y_1}$ gives us the marginal productivity of y_1 holding all other factors constant.

Factors may be considered negative products, in which case one may work only with the transformation function $f(x_1, x_2) = 0$.

If it is assumed that the marginal rates of transformation are all negative, i.e., the substitution ratios are less than unity.

Hence $\frac{\partial x_1}{\partial x_2} < 0$

Thus if x_1 and x_2 are both products, x_1 can only be increased by decreasing x_2 and likewise if x_1 and x_2 were factors x_1 can only be increased by decreasing x_2: and if x_1 is product and x_2 is a factor and increase in x_2 leads to an increase in x_1 or that marginal productivity is positive. These need hold only in effective region (that part of production function of economic significance). With these given factors and products available to the cattle feeding firm it is now necessary to consider the profit function. Under perfect competition the profit fn may be written

$\pi = P_{y_1} Q_{y_1} + P_{y_2} Q_{y_2} - C = \max.$ This is to be maximized subject to the restraint of the transformation function. The profit function may also be written simply as $\pi = R - C =$ Maximum

Where π = total profits

R = total revenue

C = total costs

$C = C_v + C_0$

Where C_v = variable costs

C_0 = fixed costs

$C_v - q_{y_2} \cdot P_{y_2} + P_{y_1} \cdot q_{y_1}$

This equation states that the total cost incurred in production of x_1 and x_2 is equal to the sum of the payments made to productive services.

(Where)

P_{y_2} = Price of corn

q_{y_2} = Quantity of corn

P_{y_1} = Price of feeders

q_{y_1} = Quantity of feeder cattle

$R = qx_1 \cdot Px_1 + qx_2 \cdot Px_2$

(Where)

qx_1 = quantity finished cattle

Px_1 = price finished cattle

qx_2 = quantity of hogs

Px_2 = price of hogs

Where profit is a maximum, subject to the constraint of the production function, marginal expenditure is equal to price of factor, marginal revenue is equal to the price of the product and inputs of factors are carried to the point where marginal productivities are equal to marginal rates of transformation times price.

Thus if it is assumed that all q's (quantities) are so selected as to have profit at a maximum, the quantities of factors and products employed will result from the following variables.

$$q_{x_1} = h_1 (P_{y_2}, P_{y_1}, P_{x_1}, P_{x_2})$$
$$q_{x_1} = h_2 (P_{y_2}, P_{y_1}, P_{x_1}, P_{x_2})$$
$$q_{y_2} = h_3 (P_{y_2}, P_{y_1}, P_{x_1}, P_{x_2})$$
$$q_{y_2} = h_4 (P_{y_2}, P_{y_1}, P_{x_1}, P_{x_2})$$

Since the objective of this study is to deal with the causes of the fluctuations in the quantity of feeder cattle demanded it is now desirable to isolate this equation and consider it. An attempt will be made to justify how changes in the given variables affect the quantity of feeder cattle taken by the cattle feeding firm.

The theory now advanced will merely be a comparison of statics, i.e., one static situation will be compared with another static situation and considering both of them in equilibrium. This will be accomplished by the introduction of a change in one of the variables upon an equilibrium position and relating the effects on the quantity of feeder cattle demanded that takes one from one equilibrium position to another.

Following the theory thus far advanced, it has been shown that the quantity of feeder cattle purchased is a function of price of feeder cattle, price of finished cattle, price of corn and price of hogs.

First let it be assumed that there is complete stability of all the variables introduced as affecting the quantity of feeder cattle taken by the cattle feeding firm. With this stability and all resources so selected as to give the greatest profit to the firm, the quantity of feeder cattle demanded, prices and marketings would remain constant from year to year.

Factor to product. Now upon this equilibrium position let there be introduced a change in one of the variables affecting the quantity of feeder cattle demanded and find what results it brings. Let there be introduced a change in the variable, price of finished cattle. Let it be assumed that there is an increase in the price of finished cattle over the equilibrium price. This increase in the price of finished cattle increases the revenue that may be obtained from the cattle feeding operation, as the price of factors (corn and feeder cattle) remains the same. Thus because of this increase in revenue and stability of marginal costs the point of profit maximization will be changed from the old equilibrium conditions and will only be satisfied at a greater output. Thus the entrepreneur will expand his cattle feeding program causing an increase in the quantity of feeder cattle demanded by the firm. The cattle feeding program will be expanded until the marginal cost of feeder cattle and corn is equal to the price of finished cattle in the market. The following diagram illustrates this point.

OA = old quantity factor used
OB = new quantity factor used
OC = equilibrium price finished cattle
OD = new price of finished cattle
K = old equilibrium output
H = new equilibrium output

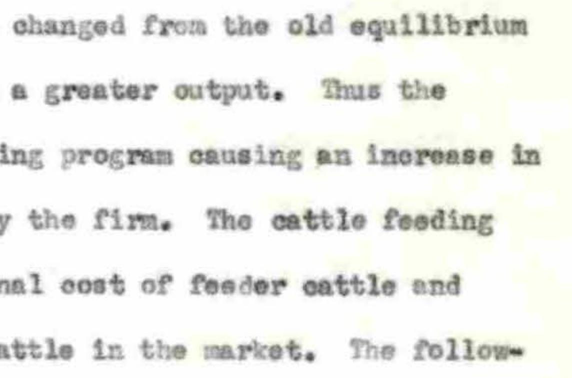


Figure 2. Equating marginal cost and marginal revenue.

For the firm to utilize the given resources most efficiently under the rise in price of finished cattle it must expand the output of finished cattle, thereby causing the quantity of feeder cattle and corn demanded by the firm to increase over quantities used under the old equilibrium position.

A decrease in the price of cattle would result in the reverse of the situation outlined above. This decrease in the price of cattle would decrease the revenue obtained from cattle feeding and thus cause the price of finished product (revenue) to equal marginal cost at a smaller output than the equilibrium position set up. This would cause a decrease in the number of feeder cattle demanded by the cattle feeding firm as a result of the drop in price of finished cattle.

Factor to factor. Another problem which must be solved if profits are to be maximized is one of optimum combination of factors to produce a given output. It is now necessary to see how changes in the prices of factors, i.e., feeder cattle and corn, affect the quantity of feeder cattle demanded by the cattle feeding firm. The optimum combination of factors may be easily expressed by formula: $\frac{Py_2}{Py_1} = \frac{MPPy_2}{MPPy_1}$ This formula states that the ratio of the prices of factors y_1 and y_2 must be equal to the ratio of the marginal physical productivity of the two factors. When this ratio is equal, the firm is considered to be in "equilibrium". Thus it is assumed that the cattle feeding firm is in equilibrium and changes in price of factors will be introduced to find how the change in price of one factor or both factors affects the output of finished cattle thereby affecting the quantity of feeder cattle demanded. This principle may be presented graphically by using a product contour. This represents the relative productivity of the two factors by indicating the marginal rate of substitution of one factor for the other. An outlay curve in the accompanying diagram will indicate the ratio between the prices of the two factors.

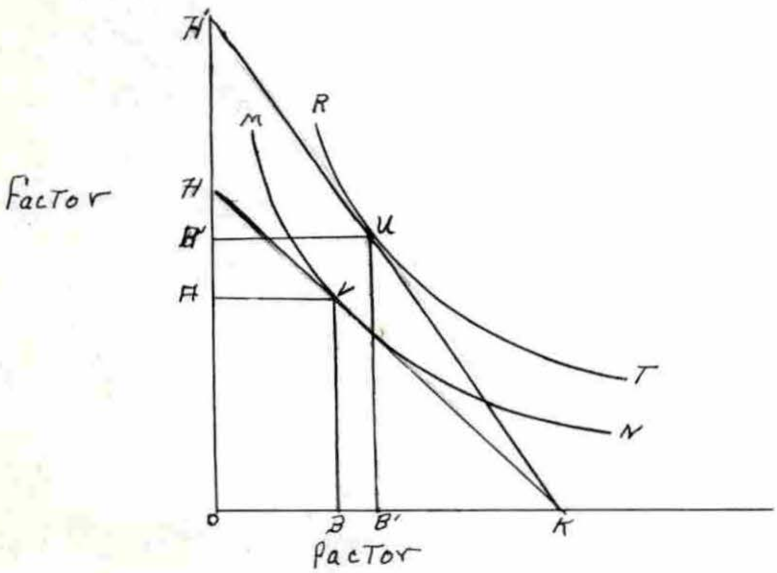


Figure 3. Least cost combination of factors.

The product contour labeled MN is a line showing the many alternative combinations of factor y_1 and y_2 possible to produce a given output of product at one given expenditure. The product contour RT refers to alternative combinations of factor y_1 and y_2 under a given expenditure when the price of one factor is changed and the other remains the same. The point of tangency between the product contour and the outlay curve represents the optimum allocation of factors y_1 and y_2 to produce Z , because it is the least cost method, also represents combination of factors at which ratio of prices and ratio of M.P.P. are equal. Thus it is shown that with a decrease in the price of factor y_1 the quantity of feeder cattle purchased will increase from OA to OA^1 and the use of y_2 (corn) will increase only slightly from OB to OB^1 and output Z will be increased. A rise in the price of factor y_1 will result in just the reverse of the above situation causing a decrease in purchase of y_1 and a slight decrease in use of y_2, and a decrease of output Z. The supply (output) of Z may be increased by a drop in price of either of the variables but the demand for factor y_2 when factor y_1 decreases in price may also increase. Here the factors y_1 and y_2 are complementary, i.e., an increase in the employment of factor y_1 also brings forth an increase in the employment in the factor y_2 even though the price y_2 remains unchanged or it may also be stated that an increase in use of one factor because of decreased price, must raise the marginal product of the other.

Thus it is seen that a decrease in price of factor y_1 when the firm is in equilibrium brings about a greater quantity of feeder cattle demanded and also a greater amount of y_2 corn demanded by the firm. A decrease in the price of factor y_2 corn would cause an increase in the employment of corn but correspondingly an increase in the amount of factor y_1 feeder cattle demanded at the same price. An increase in the price of either factor y_1 or y_2 would have just the reverse effects of procedure outlined above, causing a decrease in demand of both feeder cattle and corn.

Product to product. Another equally important problem that faces the firm is that of enterprise combination. The crux of the problem lies in deciding which enterprises (in the cattle feeding firms case hog to finished cattle) would yield the greatest net returns for the aggregate of resources (feeder cattle and corn) under the entrepreneur's control. As has been demonstrated before the optimum combination of enterprises exists when the marginal value of productivity of each factor is equated in the various lines of investment. If each dollar invested is yielding equal returns in all lines of investments then the optimum exists. Let it be assumed that the optimum exists and with the introduction of a price change in one enterprise find what the results will be on the factors used in the production. The figure below illustrates the principal of combining enterprises in the optimum manner.

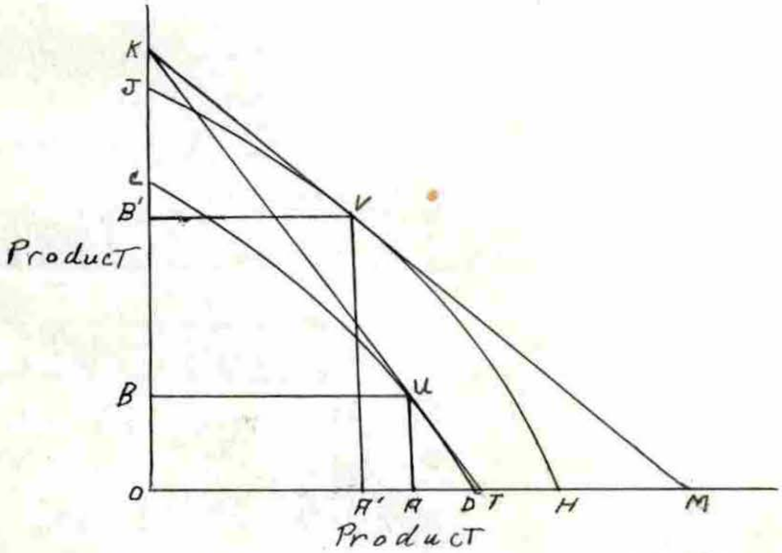


Figure 4. Determination of optimum combination of products.

This figure indicates a case in which two products (finished cattle and hogs) are competitive and substitute for each other at a diminishing marginal rate, as output of x_1 is sacrificed to produce more x_2, increasing increments of x_1 are necessary for each successive increment of x_2. The curves CD and JH show the many possible combinations of x_1 and x_2 possible from a given output of resources (costs). The straight lines K.T. and K.M. are iso revenue curves which represent all of the various combinations of x_1 and x_2 which can be marketed to bring in a given revenue. This maximum profit for a given price relationship can only be denoted by the one iso revenue which is tangent to the iso factor curve. Let it be assumed that the cattle feeding firm is in equilibrium, that is where each dollar invested is yielding equal returns in all lines of investment. Now let there be introduced a change in the price of one of the products (finished cattle or hogs) and find what results this will have on quantity of each product produced and also on the factors (corn and feeder cattle) employed. Let it be assumed that there is a decrease in the price of finished hogs x_2 with finished cattle x_1 remaining at the same price. This will change the iso revenue curve from OK-OT to OK-OM because of the increased number of hogs it will require to bring in the same revenue. Thus a new iso factor curve must be constructed which is now tangent to the iso revenue curve KM at point V. This changes the proportion of cattle and hogs from the old optimum OB of cattle and OA of hogs to OB^1 of cattle and OA^1 of hogs. Thus because of the decrease in price of hogs, the number of hogs produced by the firm decreases from A to A^1 and number of cattle produced increases from B to B^1. This is the same thing that would happen if the price of cattle increased and the price of hogs remained the same. This increase in production of finished cattle would also cause an increase in the number of feeder cattle demanded by the firm as also more corn going into the production of finished cattle. An increase in the price of hogs or a decrease in the price of cattle would result in a situation just in reverse of the one outlined above. This decrease in production of finished cattle would result in a decrease in the quantity of feeder cattle demanded and an increase in amount of corn going to production of hogs.

Hence it has been demonstrated how changes in variables affect the quantity of feeder cattle demanded by the firm under static conditions.

Theory of the firm in a dynamic setting

Considering the cattle feeding firm under dynamic conditions will permit the removal of the restricting assumptions that were necessary under the static conditions, i.e., the assumption of perfect competition may now be removed but the object of the firm is still assumed to be that of profit maximization. Now an attempt will be made to see how the omitting of the restrictive assumptions and consideration of the cattle feeding firm under dynamic conditions, might alter the theory developed under static conditions.

The theory of production under non-static conditions differs from theory under static conditions in that factors and products are dated and prices of products and prices of factors or productive agents and the transformation functions are all changing through time.[1]

Consequently the entrepreneur of a cattle feeding firm must make decisions based on expected rather than single valued prices or realized values. The probability that the expectations of entrepreneur may be realized varies from one to zero. The entrepreneur thus sets up a probability of expected prices for all factors and finished products he buys and sells. He then constructs his production plans in regard to the expected or anticipated prices. Thus the analysis of entrepreneurs or firm's behavior in such circumstances is considerably more complex than in the static model.

A rise in the price of a commodity exercises at once, only a small influence upon the supply of that commodity, but it causes the entrepreneur to speculate on whether the higher price will continue.[2] If they decide that it probably will continue they may start upon the production of a considerably increased supply for a future date. This decision will affect their current demand for factors; the current position in the factor market will thus be governed by the way entrepreneurs interpret a rise in price of market.

Similarly, the current supply of commodity, say feeder cattle, depends not so much on current price but what entrepreneurs have expected it to

---

[1]For discussions on firm in a dynamic setting see Hart, A.G., "Anticipatious Business Planning and Cycle." Quarterly Journal of Economics Vol. 51. pp. 6-15. 1937.

Hicks, op. cit., pp. 115-140.

Reder, M.W. Studies in Theory of Welfare Economics, New York, Columbia University Press, 1948, pp. 103-128.

[2]Ibid., p. 117.

be in the past. It will be these expectations, whether right or wrong, that govern current output.

This is the main crux of dynamic theory: it is first parting of ways. Hicks[1] has chosen to handle the time factor by considering inputs of a given productive agent, as in our case corn and feeder cattle, at different points in time as different productive agents and output of a given product at different dates as different products. Here he assumes transformation functions are known and the anticipations of the entrepreneur are single valued. Here resource allocation, response to alterations in anticipatious and production patterns are reached somewhat in the same way as in static situation reviewed.[2] Tintner has approached the problem under conditions where transformation functions are not completely known and where expectations are not single valued, i.e., the entrepreneur or firm has in mind a probability of different forms of the production function and a range of expected prices of factors and products. Various features of the distribution may be combined and an analysis may be handled in manner similar to Hicks.

Dynamic or non-static analysis has thus introduced expectations or anticipations, uncertainty and risk and restriction on amount of capital used or capital rationing into the analysis. This interjects the element of subjective evaluation on the part of entrepreneur into the responses

---

[1] Ibid., pp. 120.

[2] G. Tintner, "Theory of Production Under Non-Static Conditions", Journal of Political Economy, Vol. 50, pp. 645 667, 1942.

of firm to a given stimulus such as changes in relative prices. In dynamic conditions the behavior of the firm or entrepreneur to a given stimulus may differ considerably from the static model, depending on the nature of expectations. Also the entrepreneur or firm may react differently to a given stimulus in two different periods of time. However, the direction of responses to a given stimulus such as a change in prices are probably the same in dynamic conditions as under static conditions, although the magnitude of the response may differ considerably. Although the situation in which single-valued anticipations are assumed is hypothetical to a high degree,the way in which entrepreneurs respond in a dynamic situation to price and other changes will almost approximate the static situation.

The cattle feeding firm in a dynamic setting is subject to a very high risk and uncertainty which in turn is largely responsible for the capital rationing imposed. Cattle feeding to the entrepreneur is notoriously an enterprise of wide price risks. Under the dynamic setting there may be wide fluctuations in prices of factors and finished products. Whether an entrepreneur has liquid capital or credit position to finance his production plans is an important factor in the firm's demand for the factor feeder cattle. Capital rationing may be an important limiting factor in the firm's demand for the factors of production. This rationing may be self imposed (unwilling to go in debt or to use own funds) or forced on the firm by others. The extent and degree of capital rationing depends on such factors as distribution of income, degree of uncertainty and risk and credit policies. Improvements in any of these would tend toward a reduction in capital rationing, which would increase demand for factors of production and would result in a greater equalization of marginal returns for the factors of production within the firm.

In dealing with price expectations of the cattle feeding firm the past profits or losses from the cattle feeding operation affect the demand for and prices of factors used in production because they enter into the expectations of the entrepreneur in regard to future profitability and hence into their decisions to buy or not buy.[1] This would suggest for the cattle feeding firm that past losses tend to reduce current demand for factors and reasonable profitability from past operations tend to increase demand for factors. A cattle feeding firm which experiences unusual losses from past feeding operations may even retire completely for a time from the cattle feeding operation.

Cattle feeding firms, due to uncertainty and risk, capital rationing and expectations, are required to build into their firms a large amount of flexibility in order to increase profit expectations. This flexibility that must be built into the firm, tends to increase average unit costs, though it should increase profit expectations. The following diagram attempts to portray how this flexibility increases average unit costs.

---

[1]This hypothesis has been advanced by:

F.L. Thomsen, "Agricultural Prices". New York and London, McGraw-Hill Book Co., Inc. 1936. pp. 368.

H.J. Henney, "Factors Influencing the Time of Buying Feeder Steers and of Selling Them as Choice Summer Fed Steers", Kansas Agricultural Experiment Station Bulletin 258, pp. 21-22.

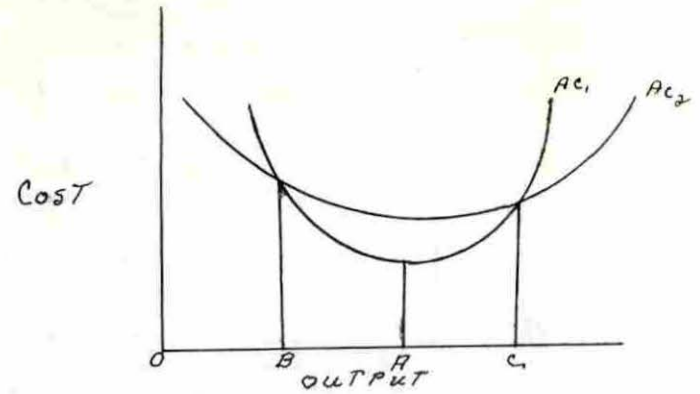


Figure 5. Comparative cost curve analysis.

The uncertainty present in the cattle feeding firm may require that the entrepreneur construct his plant with the flexibility that is demonstrated by AC_2. But if the entrepreneur was guaranteed that he would always be maximizing his profits between OB and OC he would build plant AC_1 instead of AC_2 thereby reducing his average costs.

Thus it is seen that a cattle feeding firm in a dynamic situation has much more complex problems than the firm under static conditions. A few of the conditions not present under static conditions have been discussed in the ways that might affect the entrepreneur's decision in his demand for factors. However, the theory put forth under static conditions in regard to the different variables affecting the demand of entrepreneur for factors is still valid under the dynamic situation although the magnitudes with which these variables affect demand for factors may vary considerably.

Slaughter Demand in Feeder Cattle Market

In economic theory it is shown that the demand for a commodity (such as finished beef) can be considered as a function of the price of the commodity, price of other commodities and the disposable income of the consumer. Thus by analogy, we are led to the hypothesis that the total demand for the commodity may be considered a function of all prices and of total disposable income of all consumers.

The purpose of this demand theory is to explain the behavior of consumers. Each consumer of finished beef finds himself in a given time period, with a fairly definite money income which he allocates among various commodities. If this income or other factors that affect allocation should change, then there is also a change in the consumption pattern. Thus theory develops functional relationships between factors and consumption patterns so that this change in pattern may be predicted from changes in the factors.

In setting up the model for the demand for finished beef the quantity of finished beef demanded may be said to be a function of the price of beef steers, consumer disposable incomes, prices of competing meats and price of feeder cattle.[1] All of these variables function together to formulate the price that slaughter buyers may be willing to pay for finished beef. The size and distribution of income plays a very important part in the dollar value of meat purchased. With a given supply of meat

[1]U.S. Bureau of Agricultural Economics. "Agricultural Outlook Charts". p. 16. 1940.

the consumer demand for meat - and thus its price, is determined largely from how much money people have and the distribution of the income or who has it.

Packing plant buyers at times compete with the entrepreneurs of cattle feeding firms for the heavier feeders with better finish, but not usually for the lighter and poorer grade feeder animals. In most years this is not especially important but it does tend to keep feeder prices rather close to the common and medium slaughter grade cattle and calves. Only a portion of the total market supply of cattle is desirable for a feeding program, but at the same time these cattle have considerable market value for immediate slaughter. Therefore, the cattle feeder is in direct competition with the slaughter buyer for this distinctive group of so-called "two way" cattle. This competition may be noticed in years following restricted operations, by the cattle feeding firm because of weather or other causes. The slaughter buyer, in order to purchase his beef requirements, will be forced to buy more light and unfinished cattle that might otherwise go to the cattle feeding firm. This causes the entrepreneur of the cattle feeding firm to pay a somewhat higher price than would otherwise be necessary for the factor feeder cattle, in order to carry on his cattle feeding operation.

Thus it may be seen that slaughter demand plays a definite role in the quantity of feeder cattle that the entrepreneur can or may or be willing to purchase for his operations. Slaughter demand is not considered in the statistical model that will be set up later or in the previous discussion on the factors affecting the demand of feeder cattle by firm, but its importance justifies it at least general consideration as to how this slaughter demand might affect the quantity of feeder cattle that may be purchased by the cattle feeding firm.

Theory of the Supply of Feeder Cattle

Having considered the demand for feeder cattle by the cattle feeding firm and slaughter buyers it is now in order to evaluate the supply side and find just how supply affects the quantity that may be purchased for the cattle feeding operation. The number of cattle available for feeding operation is especially relevant to the entrepreneur of a cattle feeding firm. Even if the expectations of the entrepreneur for feeding operations are very good and the number of cattle available is limited then the quantity he purchases is also restricted even though he may prefer to feed more cattle. The cattle feeding firm can purchase no more than the suppliers of feeder cattle are willing to offer in any one year.

The supply of feeder cattle to the cattle feeding firm comes from importation from other states and cattle raised domestically. The supply of cattle from the range states is very important to cattle feeding firms in Iowa, as Iowa is the principal importing state.

Although feeder cattle are one of the principal inputs of the cattle feeding firm, they are the principal output of cattle breeding firms. The output or supply of feeder cattle may be said to be a function of range conditions, number of head of cattle on farms and ranges in producing area, price of feeder cattle and price of competing enterprises.

Producers' expectations of future prices may also very greatly affect the supply of feeder cattle. The current supply of feeder cattle depends not so much upon what the current price is as what entrepreneurs have expected it to be in the past. It is those past expectations, whether right or wrong, which mainly govern current output; and the current price has only a small influence.[1]

The two most important factors influencing the supply of feeder cattle on the market appear to be range conditions and number of cattle in the producing area. Range conditions consist primarily of pasture and other grazing and forage crops. Grass is a fixed resource and a cattle breeding firm must make full economic use of grass at all times. Favorable range conditions may cause the entrepreneur to hold back some of his yearling heifers for breeding purposes, and also increase the average market weight of other feeder cattle through an extended feeding period, which would decrease the number available to the cattle feeding firm. Range condition is probably the principal determinant of market supply of feeder cattle in the short run, while the principal long-run determinant is the fairly regular cyclical changes in number on farms resulting from the changing expectations and plans of producers. The greater the number of cattle on farms the greater will be the number of feeder cattle, that can be offered for sale to the cattle feeding firm in any one year. The number on farms are in the long run a result of entrepreneurs' expectations of profitability of feeding and breeding based on projections

---

[1] Hicks, op. cit., p. 117.

into the future of current prices and price ratios. There are also more or less random short-run influences affecting numbers on farm and marketings, chiefly weather induced fluctuations in yields of grass and forage crops, prices of feeders and prices of competing enterprises. All of these variables influence the decisions of producers to increase or decrease numbers on their firms. Decisions to increase the numbers on farms leads to a current decline in marketings, to increased prices of feeder cattle and increased farm values and in some cases further decisions to increase number and production on firms. The cycle may then turn down again due to random fluctuations, caused by feed restrictions and the lowering of prices due to realizing the production plan that was entered upon much earlier. In the past the lengths of these interrelated cycles in the number on farm, farm value, and marketings have been about 15 years in duration. This appears to be a function of the time required for gestation plus the average marketing age.

Prices for feeder cattle affect current marketings indirectly through their effects on producers' returns and expectations, which in turn influence decisions to increase or decrease herds and hence current to future marketings and prices.

Prices of competing enterprises may also play an important part in the fluctuation in supply. Favorable prices for competing enterprises may cause an increase in current marketing of feeder cattle but will show up as a decreased supply in future marketings because of the partial liquidation caused by the favorable prices of competing enterprises.

As has been shown periodic changes in cattle numbers are usually both economic and physical. Most writers agree and actual data substantiate the above hypotheses. There is a time lag between the decision to increase production (decrease supply of feeders) and marketing of the product resulting from that decision (increase number available at end of production period).[1]

An attempt will now be made to construct a theory for the variables given as affecting the fluctuations in the supply and to make clear the nature of interrelationships among value, marketings and number on farms.

First, let it be assumed that there is complete stability of everything that affects the value of cattle, likewise range conditions and numberless other factors must be stabilized. Assuming this stability, cattle numbers, prices and marketings would remain constant from year to year. Now into this equilibrium let there be introduced a disturbance such as an improvement in range conditions which will react upon the decisions of entrepreneurs and according to the theory advanced will cause an increase in the breeding herd. This decision on the part of the entrepreneur to accumulate animals, will result in a decline in the number of cattle marketed and thus a limited number available to cattle feeders and slaughter buyers. This will in turn cause an increase in the

---

[1]For discussions on fluctuations in cattle numbers see:
Shepherd, G.S., "Agricultural Price Analysis", Ames, Iowa State College Press. 1941, pp. 43.
Thomsen, F.L., "Agricultural Prices", New York and London, McGraw-Hill Book Co., Inc. 1936. p. 366.
Op. cit., Hopkins, "Statistical Study of Prices and Production of Beef Cattle", pp. 10-12.

value of animals marketed and the price of feeder cattle to the entrepreneur. Thus this disturbance has resulted in an accumulation of animals on farms, decline in marketing and a rise in value of animals marketed.

To this increase in price of marketed cattle the entrepreneur of cattle breeding firms may react in one of two ways; he may increase his marketings at the expense of liquidation of a portion of his herd or he may increase his herd at the expense of decreased current marketings in the hope of increasing production and profit expectation in the future. Evidence available seems to indicate that the cattle breeding entrepreneur has reacted in the latter fashion, i.e., when price of cattle has risen above a trend or normal line, farmers have tended to increase the number of cattle kept on the farm. Applying this model it will be seen that the initial decline in marketing and a rise in price would create further accumulations on farms, further decreases in marketing and further rise in values. This disturbance due to an exogenous factor, created changes which in themselves generated further changes in the same direction, a direction away from the initial equilibrium. It might be suggested that a rise in price of feeder cattle due to an increase in demand would give the same results. There might be a time lag between rise in value and beginning of accumulation.

vice versa

Animals held back to increase production and increase future marketings may not appear on the market for 2-1/3 or 3 years after initial expansion. This reverses the downward trend in marketing and causes value to decline. It is generally agreed that entrepreneurs will continue to expand their herds as long as prices and expectations are favorable. The downward effect of prices will have its effect in lessening the rate of expansion and marketings will increase as productivity capacity of herd increases and as increments to the herd decrease. These further increases in marketing will be accompanied by declines in prices and further lessening of the rate of expansion. When marketings have increased to the equilibrium level, prices will also decline to this level, and cattle numbers will have reached their peak.

Marketings will continue to rise because of the peak level of breeding herds and because part of the animals will no longer be withheld from market to increase cattle inventories. When prices go below initial equilibrium it will cause some liquidation of existing herds. Thus the number of cattle will start to decline for first time - since initial disturbance. When number on farms reaches equilibrium level, marketings will have reached their peak and cattle prices their nadir. Because of large marketings of breeding stocks and lessening flow to market of young stock - marketings will therefore start to decline and with this decline a reversal of downward movement. Liquidation will continue until prices are once again at equilibrium.

Marketings will continue to decline and prices rise until they simultaneously reach equilibrium point. At this point cattle numbers will be at their lowest. The rise of values above equilibrium will start expansion of inventories again - thus the cycle is completed in 14-16 years.

This model may not be precisely significant over any period of time and was constructed only to indicate the nature of the cattle production process and provide a background in order that exogenous factors may be appraised.

ESTIMATION METHODS OF THE DEMAND FOR FEEDER CATTLE

As stated previously in economic theory it is shown that the demand for a commodity can be considered as a function of the price of the commodity, the prices of other commodities and disposable income of the consumer. The chief difference between the theory of production and theory of consumption is that the total quantities of the consumer's goods in the market are no longer the givens of the problem but must themselves be determined. These givens are instead, the quantities of the productive services and the state of technology, i.e., the production function.

The assumption is made for consumers that their expenditure is fixed regardless of what prices of the goods may be, but as has already been emphasized, the theory of producers demand differs from that of consumer's demand in that the total expenditure of the producer varies as price of the services or of the product vary.

In order that the model proposed in the theoretical section may be evaluated, two methods of estimating the parameters of the demand equation will be attempted. The first method to be employed will be that of using simultaneous equations to estimate the parameters. This will be accomplished by considering both the demand and supply equation by the instrumental variable "Just Identified" approach and then employing the limited information approach where all variables in demand and supply equations may be considered at the same time. The second method to be employed will be that of the single equation least squares method using only the demand equation.

Survey of the Simultaneous Equation Method of Statistical Analysis

In order to study the mutual interdependence of the various parts of the economy, it is necessary to establish the complete, determinant system of relations that ties the various economic variables together. This idea has a strong basis of tradition in economic theory dating back to the physiocrats and later theories of Leon Walras. In modern time the interest of many economists has been directed toward investigations into the quantitative nature of the dependence between economic variables. Realizing fully the need to tie all of the economic variables in the system together the simultaneous equation approach was attempted.

Through the simultaneous equation method the economic system is viewed as describable by a set of simultaneous equations expressing all interrelationships among measurable economic magnitudes which guides economic behavior. The variables used in this system are classified as either endogenous or exogenous. Endogenous variables may be defined as variables that are determined within the system of narrow economic forces. They may also be defined as variables that are determined by a whole system of interacting economic forces. These endogenous variables are sometimes given the name of jointly dependent variables. Exogenous variables may be considered given by forces outside of the narrow confines of the economic system, i.e., they are independent of the functioning of the economic system and are not capable of being affected by the economic system: These variables are determined by forces which are assumed to be external to the system under consideration.

In the study to follow the price of finished cattle, price of hogs, price of corn, number of cattle in the producing area, and range conditions will all be treated as exogenous variables and the price of feeder cattle and number of feeder cattle imported into Iowa will be considered as endogenous variables. This procedure may be questionable in some instances, but for this study the variables will be considered in the categories indicated.

Economists have, over a period of years, developed theories of economic behavior which are the basis for the determination of the endogenous variables. Economists do claim to know how an entrepreneur reaches his decisions as to how much of a product he will supply in the market given prevailing conditions. Entrepreneurs, households and speculators are assumed to behave according to some fundamental rational pattern which can often be written in the form of mathematical equations.

This system is said to be complete when the entire set of structural equations are just enough in number to determine all of the endogenous variables given the exogenous variables. A complete system may be defined as one that has as many equations as it has endogenous variables.

In the study to follow there is a disturbance u_1 attached to the equation to show that human behavior is not exact but subject to random fluctuations. This u_1 signifies the joint effects of all omitted factors.

These variables are not observable so therefore not quantifiable and to handle them correctly it is better to get a probability distribution of these disturbances. Assumptions of normal distribution, with mean zero and finite variance may be made to eliminate the impossible.

A very interesting observation about the procedure to be used in this study is the fact that one never has to make a choice between the dependent and independent variables in the sense of the regression theory. In the simultaneous equation approach it is necessary to classify the variables into endogenous and exogenous variables on economic grounds but once this decision is made the economist or the statistician proceeds with the simultaneous equation method of estimation unambiguously.

Thus is left behind the question of early day econometricians, mainly whether to take a regression of price on quantiy or quantity on price. The older method always produced inconsistent estimates in the two variable problem. The system to be employed in this study is a complete system which gives unique estimates of the parameters.

The reason why it is possible to transform uniquely from the estimates of instrumental variable or reduced form coefficients in the simple example to structural parameters is based on a very fundamental concept in econometrics - that of identification. If each linear equation has a unique predetermined variable and is not subject to any other restriction, then the system is just identifiable or identified.

The procedure that has been followed in this study is to first formulate the economic theory and from it, the structural equations. The equations were then examined for identification to determine the statistical techniques that should be employed.

Simultaneous equation vs. single equation

The next step will be an attempt to justify the use of the simultaneous equations in this study instead of the single equation least squares approach. An attempt will be made to portray the advantages of simultaneous equations over the single equation.

The approach to economic models adopted in this study has been developed only in recent years particularly by members of the Cowles Commission staff.[1] Formerly economists singled out an isolated equation of the economic system and attempted to estimate structural parameters by the method of a single equation or some other simple method whose statistical properties were not always satisfactory. When earlier statisticians fitted their equations to the data by the method of least squares they seldom knew in which direction they should minimize their sum of squares, i.e., which should be the independent and dependent variables. They were aware of the identification problem but never solved it adequately.

Now many of these matters are cleared up. If one specifies both the economic and statistical properties of the model and treats the set of equations as a unit, instead of treating each equation in isolation from

---

[1] For publications in regard to econometric models see:

Tjalling Koopmans, "Statistical Estimations of Simultaneous Economic Relations", Journal of the American Statistical Association. Vol. 40. pp. 448-456. 1945.

Trygve Haavelmo, "Methods of Measuring the Marginal Propensity to Consume", Journal of the American Statistical Association, Vol. 42. pp. 105-122. 1947.

M.A. Girshick and Trygve Haavelmo, op. cit., pp. 79-110.

Trygve Haavelmo, "Quantitative Research in Agricultural Economics: The Interdependence Between Agriculture and the National Economy", Journal of Farm Economics. Vol. 29. pp. 910-924. 1947.

Gershon Cooper, "The Role of Econometric Models in Economic Theory", the remainder of the system then one is not confronted with the same problems that were formerly troublesome.

In order to specify the economic properties of the model, it is necessary to know the form of all equations that connect the several variables of the system, i.e., it is necessary to know which variables should be included and which are endogenous and which are exogenous. The statistical properties of the model are the assumptions that must be made about their disturbances, their relationship to economic variables, their distribution, their auto correlations, inter-correlations, etc. The model must be specified in advance and appropriate statistical methods can then be determined.

The instrumental variable method and the limited information method have the advantage that all equations of the model need not be known entirely in order to estimate the parameters of any single equation. In the single equation on which attention is centered it is necessary to know whether the variables are endogenous or exogenous.

There are many unsolved problems inherited from earlier days and some new ones created by new models. Multicollinearity was and still is a problem. Where economic variables move together in the same general time patterns it is not possible to measure separate influences in the equations of the system.

Journal of Farm Economics. Vol. 30. pp. 101-116. 1948.

T.W. Anderson and Herman Rubin, "Estimation of the Parameters of a Single Equation in a Complete System of Stochastic Equations". The Annals of Mathematical Statistics. Vol. 20. pp. 46-63. 1949.

The new method is very laborious and complex in computation. Although very economical techniques have been developed for multiple correlation computation the use of this method is restricted except in special cases where one is assured that the independent variables are not considered dependent in some other part of the model. The limited information method for the over identified case is very sensitive to small computational errors and for adequate results some of the computations must be carried out to at least six places. The theory behind the simultaneous equation approach is quite rigorous, but it is not the purpose of this study to go into detail concerning the theory and technique of the new method.

Further Considerations in Future Model Construction

Before proceeding to set up the model it is now in order to offer suggestions to future research workers in this field. Future research workers should be warned of the mistakes and shortcomings of the study made so as to avoid some of the difficulties which are recognized by the writer.

This model is based on a finite sample of the population involved, i.e., a sample which covers only a limited number of years. This was made necessary as stated previously by the lack of adequate data. In future research on cattle feeding a number of other factors may be used on the demand side. Only the variables found to be most relevant by *a priori* knowledge and multiple correlation analysis were included in the demand equation.

In taking the supply side into consideration, only two exogenous variables were considered. The future research worker should consider other exogenous variables from the supply side in order to arrive at a more dependable estimation of the parameters of the demand equation. The demand for slaughter cattle as stated in a previous section of the study may also be of importance in estimation of the parameters of the demand equation. In future research, factors that affect slaughter demand, such as total disposable income, should be included so as to evaluate its effect on the demand for feeder cattle.

Because of the limited time available for this study the actual prices were used for factors appearing in the demand equation. Future research may be improved by the use of price ratios because entrepreneurs appear to base their decisions on price ratios rather than actual prices. Perhaps also a larger system of equations should have been used so as to take into account interdependence with other markets.

One is not justified perhaps in assuming all variables except price and quantity of feeder cattle in the demand equation as exogenous. For example, the price of finished cattle may upon further study prove to be really endogenous. The model to be presented was constructed with the consideration of only one area. In future research no doubt a larger portion of the cattle feeding area should be considered instead of isolating one segment of the complete area. The model to be proposed was found to be inadequate in estimating the parameters of the demand equation for the seven cattle feeding states for which data are available.

Confidence regions or limits were not placed on the parameters estimated but confidence regions for the coefficients of one equation may be obtained on the basis of small sample theory. This should be taken into consideration in future research in order to judge the reliability of the estimates obtained.

It is the hope of the writer that these suggestions may be utilized by men doing further research in regard to feeder cattle in Iowa as well as in a larger segment of the feeding area. These are not intended to be expressed as limitations to the study made but rather as a guide to those who may do comparable studies in this field.

Theoretical model proposed and carried through

Any statistical method of estimation derives its meaning and area of applicability from the concept of a well defined economic model. This is true even if, as in the estimation of economic relations from time series, the sampling is performed by the historical course of economic phenomena, outside the statistician's influence. Even though the available sample is unique and "repeated samples" exist only in one's imagination, such commonly used terms as "unbiased estimate", "bias", and "standard error of estimate" have a meaning only in relation to such an imagined sampling process.

The simultaneous method of estimating economic relations has been used as a starting point in this study and will later be used as a basis of comparison with the single equation method. The first model to be introduced will be a two equation system using the "limited information" method for an over identified case.

In the beginning of this chapter it was said that for statistical purposes the observable variables occurring in the systems of economic relations can be divided into two groups: the jointly dependent variables and the predetermined variables. In a complete system it is possible to solve for each of the jointly dependent variables in terms of the predetermined variables and the random residuals. Solving in this way is the "reduced form" method of solution of a simultaneous equation system. The name given the system employed in this study is the "limited information" method and is used because the equations on which the study is based are over identified. In the mathematical model each jointly dependent variable in a given equation is expressable as a linear function of all the predetermined variables occurring in the system.

Theoretical model of the demand of feeder cattle

In the theoretical model advanced in the preceding chapter it was assumed that the quantity of feeder cattle demanded may be considered a function of the price of factors of production, price of the product and price of the competing products.

$$Q = f(P_1 \; P_2 \; \text{-----} \; P_n)$$

where Q = quantity demanded

P_1---P_n = prices of factors of production, finished product, and competing enterprises.

Having proceeded on the basis of this theory it is now possible to set up a mathematical model for the demand for feeder cattle using the following time series. Let the following symbols be introduced.

y_1 = number of feeder cattle imported into Iowa from August given through July following year, in thousands

y_2 = price of feeder steers all weights and grades at Kansas City from August of given year to July following year per hundred

Z_1 = price of finished steers Chicago all weights and grades from August of given year to July of following year per hundred

Z_2 = price per bushel of number 3 yellow corn at Chicago from August of given year to July of following year per bushel

Z_3 = price of barrows and gilts at Chicago from August of given year to July following year in dollars per hundred

The above variables used were found to be the most relevant when setting up the model for the demand equation. The model was constructed so as to conform with what is a production year in feeding cattle, i.e., from August of a given year through July of following year. Due to lack of dependable data on the price of barrows and gilts in Chicago, it was necessary to limit the observations to production years beginning in 1938 to 1947 inclusive. In Iowa the most important factor of production to be considered is corn and this will be represented in the model as price per bushel of number 3 yellow corn at Chicago. Hogs are considered to be the chief competing enterprise to beef cattle and it was therefore logical to include the price of hogs, using the price of barrows and gilts, thus covering a broad segment of marketable hogs. The average price for all weights of feeder steers was taken from Kansas City because this is the largest terminal market for feeder cattle and also because this was the only readily available price series dating back to 1938. Chicago was chosen as the typical market for finished steers, and prices of all grades were chosen so as to include the broadest possible segment of finished cattle originating in Iowa. The quantity of feeders imported

Table 1. The basic data of the statistical analysis of the demand for feeder cattle[1]

Year	Price of feeder cattle[a] all weights & grades at Kansas City	Number of feeder cattle imported into Iowa[b]	Price of finished steers all weights & grades at Chicago	Price of number 3 yellow corn at Chicago[d]	Price of barrows and gilts[e] at Chicago	Number of cattle on ranges and farms Jan. 1[f]	Range conditions July 1st[g]
	($ per 100 pounds)	(000 omitted)	($ per 100 pounds)	($ per bushel)	($ per 100 pounds)	(000 omitted)	(per cent)
1938	8.20	901	10.02	.495	7.53	28,222	87
1939	8.24	1,067	9.64	.575	5.90	28,240	78
1940	9.45	1,175	11.25	.667	7.83	29,004	85
1941	10.72	1,038	12.48	.791	12.42	30,875	95
1942	13.09	1,055	15.21	.943	14.63	33,758	89
1943	11.95	971	15.29	1.123	13.84	37,020	86
1944	12.68	1,104	15.80	1.139	14.62	39,177	87
1945	14.25	1,025	17.02	1.282	15.08	39,446	85
1946	18.57	1,324	23.17	1.723	23.30	37,920	82
1947	24.52	937	29.99	2.386	24.78	36,864	88

[a]Source: U.S. Bureau of Agricultural Economics. "Livestock Meat Situation". Nov. 1948.

[b]Iowa Department of Agriculture. "Iowa Agriculture-Livestock, Poultry, and Dairy." Bul. 92.4 p. 16. 1945. Also "Crop and Livestock News", February 1948-1949.

[c]U.S. Production and Marketing Administration. Livestock market news statistics and related data 1938-1947 issues.

[d]*Ibid.*, 1947. p. 68.

[e]*Ibid.*, 1940-1947.

[f]Livestock and Meat Situation. March 1949.

[g]U.S. Bureau of Agricultural Economics. "Western Livestock and Range Report (17 western states) monthly 1938-1947.

[1]Annual price is arithmetic average of monthly data for August of given year to July of following year.

constitutes all of the feeder cattle brought into the state from other areas during the production year.

Assuming the demand function to be a linear function of the relative price of factors of production, price of finished product and price of competing products one is then led to the hypothesis

$$y_2 = \beta y_1 + \gamma_1 z_1 + \gamma_2 z_2 + \gamma_3 z_3 + \gamma_0 + u_1$$

The β's and γ's are constants and u_1 is a random residual (a random shift) for each time period considered. It will be noticed that in the demand equation there are two simultaneous or jointly dependent, variables, i.e., variables that have to be explained by other relations in the economic system, while the variables z_1, z_2 and z_3 may be considered as given or predetermined, in the sense that they are stochastically independent of the random variable u_1. It is assumed that there is no serial correlation in the residual u_1.

Supply of feeder cattle by entrepreneurs

For the supply of feeder cattle one might consider the current output as a result of decisions based on past prices, and other variables not related to the current market situation such as range conditions, available acreage, range grazing laws, etc. These entrepreneurs undoubtedly have, on the other hand, some possibilities of instantaneous adjustment to the current price situation. They can speed up or slow down the accumulation of cattle on range and increase or decrease their breeding stock. When annual data are used it would therefore seem necessary to include current prices as a variable influencing the supply of feeder cattle. A theory of the behavior pattern of the cattle breeding firm has been reviewed in the preceding section. A technological change in production such as improved pasture mixtures or hay varieties might account for a trend. The following equation might be considered as an approximation of the farmer's supply equation

$$y_1 = \alpha y_2 + \epsilon z_4 + \epsilon z_5 + \epsilon_0 + u_2$$

where the random residual u_2 might be expected to be large particularly because there is no variable accounting for the full influence of weather. The variable z_4 introduced in the supply equation is the condition of the range on July 1 of a given year. The variable z_5 introduced in the supply equation is the number of head of cattle on farms and ranges of 17 western states on January 1 of a given year.

This supply equation does not explicitly take account of the effect that the prices of competing enterprises might have on supply. One way to account for this is to include the previous year's prices of any competing enterprise. This leads to

$$y_1 = \alpha y_2 + \epsilon_1 z_4 + \epsilon_2 z_5 + \epsilon_3 z_6 + \epsilon_0 + u_2$$

where the variable z_6 is the previous year's price of the competing enterprise.

If one were interested in a more detailed study of the determinants of the supply of feeder cattle the first two supply equations advanced would not be adequate behavior patterns for the production policy of the farmers. It would then be necessary to study production functions, principles of profit maximization, etc. These two supply equations might, to some extent, be considered as derived equations, the parameters of which are obtained from certain decision functions.

For the purpose of studying the demand for feeder cattle one might even consider a much simpler hypothesis, namely

$$y_1 = \alpha y_2 + \epsilon_1 z_4 + \epsilon_2 z_5 + \epsilon_0 + u_2$$

Both variables z_4 and z_5 will be considered as exogenous or predetermined. One might think of the supply of feeder cattle as being practically independent of the current market situation. Such a hypothesis as this is obviously not strictly true of course.

The Limited Information Statistical Analysis

Thus it is seen by considering y_1 as a jointly dependent variable it is necessary to study not only the demand function for feeder cattle but also the supply function for this product. The system to be employed in estimating the parameters of the demand equation with the limited information approach results in the following structural equations for the demand and supply functions.

$$D: y_2 = \beta_1 y_1 + \gamma_1 z_1 + \gamma_2 z_2 + \gamma_3 z_3 + \gamma_0 + u_1$$

$$S: y_1 = \alpha y_2 + \epsilon_1 z_4 + \epsilon_2 z_5 + \epsilon_0 + u_2$$

The coefficients of the demand equation will now be estimated from the above equations so as to obtain information as to how the variables entering into the system of equations affect the price of feeder cattle and ultimately the amount which the cattle feeders in Iowa will demand under different magnitudes of the variables. It is seen that the answers to such questions cannot be obtained by considering any one of the equations taken alone and thus the equations must be considered as a system. The obvious method is to solve the system of equations and express each of the variables in terms of y_2. The solutions turn out to be fairly complicated and space will not permit giving them. Only the principal results of the estimates will be presented.

The estimation of the parameters of the demand equation from the system of equations resulted in the following coefficients for the unknowns:

$$y_2 = -.001435y_1 + 1.007969z_1 - 2.3136z_2 - .003582z_3 + 1.1970$$

with a $\sigma^2_{y^2}$ of .005296

Using these coefficients the following values of respective elasticities are obtained and are valid when the values of the variables involved are close to their values in the period under consideration.

$$\frac{\partial y_2}{\partial y_1} = -.0014$$

$$\frac{\partial y_2}{\partial z_1} = 1.0080$$

$$\frac{\partial y_2}{\partial z_2} = -2.3136$$

$$\frac{\partial y_2}{\partial z_3} = 0.0036$$

Stating the results in words it would read as follows: An increase of one unit in the given variables would result in the following.

(1) An increase of 1000 head of cattle imported would bring a decrease in price of feeders of .0014 cents.

(2) An increase in price of finished cattle of one cent would increase price of feeders 1.008 cents.

(3) An increase in price of corn of 1 cent per bushel would cause a decrease in price of feeder cattle of 2.313 cents.

(4) An increase in price of hogs of 1 cent would decrease the price of feeders by .0035 cent.

In order to get the meaning of the coefficients given it is necessary to know in what units the series are measured or what is the standard deviation of the different variables. The standard deviations of the variables in the time series used are as follows:

σ_{y_2} = \$5.52 per 100 lbs.

σ_{y_1} = 120,000 head of feeder cattle

σ_{z_1} = \$6.33 per hundred pounds

σ_{z_2} = \$.549 cents per bushel

σ_{z_3} = \$6.26 per hundred pounds

Stating these standard deviations in words and using the coefficients obtained from the demand equation shows the following results.

(1) A rise in the number of feeder cattle imported of 120,000 head will result in a fall in the price of feeder cattle of \$0.17.

(2) A rise in the price of finished cattle of \$6.33 would cause a rise in the price of feeder cattle of \$6.38 per hundred pounds.

(3) A rise in the price of corn of \$.55 would cause a decrease in the cost of feeder cattle of \$1.17 per hundred pounds.

(4) A rise in the price of hogs of \$6.36 would cause a decrease in the price of feeder cattle of .02 per hundred pounds.

This should serve to give the reader a view of how the resulting equation operates and also bring out the importance of the different variables in regard to the demand by entrepreneurs for feeder cattle.

The reliability of these conclusions depends of course upon the accuracy of the statistical measurement of the parameter involved, their sampling error, confidence regions and sample test of restrictions and much careful research is yet to be carried out to check the tentative estimates that have been used. But the preliminary results might perhaps serve as an illustration of the type of analysis that would be required in order to study the final net effects of certain changes in the structure of this segment of the economy.

Comparison of results with theory

It is now possible to draw from the findings of the limited information method of estimation some significant conclusions regarding the effects of each of the four exogenous variables on the price of feeder cattle. The first hypothesis submitted in the preceding chapter was that the price of feeder cattle is affected positively by the price of finished cattle. The statistical analysis agrees with this postulate and also emphasizes the importance of finished cattle prices in regard to feeder cattle prices. The magnitude of this positive effect in the equation results in a coefficient of 1.0080 of the price of feeder cattle on the price of finished cattle with the other variables held constant. This means precisely that in the period from 1938-1947 a change of 1 cent in the price of finished cattle has been responsible for an increase in the price of feeder cattle of 1.008 cents. In view of the facts with respect to the pricing of feeder steers and finished cattle, these statistics appear to be quite reasonable. Thus as hypothesized earlier the demand by slaughter buyers tends to keep the prices of finished cattle and feeder cattle rather close together and one would expect them to move in the same direction. This also tends to give support to the theory that the price of the factor rises more than the price of finished product. Entrepreneurs appear to respond quickly to a rise in the price of finished steers. With a greater rise in price of finished cattle they are willing to pay more for the feeder cattle or a decrease in the price of finished cattle would result in just the reverse.

The second hypothesis put forth is that the price of feeder cattle reacts negatively to the price of corn, i.e., as the price of corn advances with other factors being held constant, the price entrepreneurs are willing to pay for feeder cattle decreases. The statistical analysis appears to agree with this postulate. The magnitude of this negative effect is a matter which has never been determined satisfactorily and it is not claimed that the statistical analysis presented here has provided conclusive answers on this point. In the period from 1938-1947 a change of 1 cent in the price of corn has been responsible for a change in the price of feeder cattle of -2.313 cents. This magnitude appears to be quite reasonable in view of the facts with respect to the price of feeder cattle, and seems to bring out that the price of corn is one of the most important variables affecting the price of feeder cattle and, ultimately, the demand by the entrepreneur.

According to the statistical analysis, changes in the price of feeder cattle were negatively associated with changes in the price of hogs. This agrees with the hypothesis advanced that the price of feeder cattle is influenced negatively by the changes in other products which may be produced by the firm. In the period from 1938 to 1947 a change of 1 cent in the price of hogs was responsible for a decline in the price of feeder cattle of -.0036 cent when all other factors are held constant. The price of hogs plays an important part in the decisions of entrepreneurs as to what enterprise to select for a given year and also as to what price he will be willing to pay for factors of production. Although the magnitude of the coefficient is very low it cannot, however, be ignored because the price of hogs is very important to firms which have a high degree of flexibility as to enterprises that are included in their system for any given year.

The statistical analysis also brings out the fact that changes in price of feeder cattle are negatively affected by the number of feeder cattle imported into the state. This appears to agree with the hypothesis advanced which stated that the higher the price of feeder cattle the less farmers are willing to import for feeding, holding other factors constant. This appears to be very realistic and the coefficient states that a change of 1000 in the number of feeder cattle imported will result in a reverse change in the price of feeder cattle of .0014 cent. This appears to bear out the fact that the importations of feeder cattle seem to remain relatively stable through the time period considered and that the number of feeder cattle imported has but very little effect on the price of feeder cattle.

Thus the statistical techniques applied seem to validate the theory on which this model is based. In order to judge the reliability of the estimates of the different parameters it would be desirable to compute confidence intervals. The method employed gives one a logical and consistent estimation procedure. Much careful research both in economic theory and statistics is yet to be carried out before one can draw final practical conclusions from the results obtained. The limited information method ignores a certain amount of information as the estimates obtained are not asymptotically as efficient as a full maximum likelihood approach. For all practical purposes, however, the limited information method is best since a full maximum likelihood procedure in an over-identified system is extremely complex.

The "Just identified" Instrumental Variable Analysis

Having given the results of the limited information method of estimating parameters it is now in order to compare this method with other statistical techniques in order that the reader may see just why the limited information approach was used.

The second method to be employed will be that of using one instrumental variable from the supply equation in the "just identified" case. The system of equations which is to be used in this analysis is as follows:

$$y_2 = \beta y_1 + \gamma_1 z_1 + \gamma_2 z_2 + \gamma_3 z_3 + \gamma_0 + u_1$$

$$y_1 = \alpha y_2 + \epsilon_1 z_4 + \epsilon_0 + u_2$$

When the system is "just identified" as will result from this system of equations the limited information approach may be used but the "just identified" instrumental variable method is simpler and easier to handle giving identical results. This method will now be used by working with two different instrumental variables. The first method of estimation by the instrumental variable consisted of using the variable z_4 from the supply equation. The variable z_4 was defined in the preceding section of this chapter as the number of cattle on farms and ranges of the 17 western range states as of January first of a given year. Using this variable the following estimation equation was obtained:

$$y_2 = .0025_{y_1} + 1.0888_{z_1} - 2.0240_{z_2} - .1183_{z_3} - 2.7180$$

It is seen that this equation differs somewhat from the estimation equation obtained from the limited information method. Using only one variable from the supply side has resulted in a change of sign and magnitude of the y_1 coefficient. This appears to suggest that the price of feeder cattle and number of cattle imported move together, i.e., a change in the price of feeder cattle would result in a change in the same direction in the number of feeder cattle imported. This does not agree with the theory advanced and does not seem logical. The cause of this change in the coefficient of y_1 is in part due to the fact that it is assumed that the numbers of cattle in the producing area are practically independent of the current market situation. This is of course not strictly true in the model proposed and therefore the estimation of the parameters by using only one instrumental variable would have to be made with caution. The remaining coefficients for z_1, z_2, and z_3 agree with the "limited information" method in signs but the magnitudes differ slightly. The greatest change in the coefficient is that of z_3 which gives the effect of the price of hogs on the price of feeder cattle. This method of estimation increases the importance of the price of hogs as a variable and slightly decreases the importance of the price of corn in regard to the price of feeder cattle.

A second method of estimation with the "just identified" case was attempted, using the following system of equations:

$$y_2 = \beta y_1 + \gamma_1 z_1 + \gamma_2 z_2 + \gamma_3 z_3 + \gamma_0 + u_1$$

$$y_1 = \quad y_2 + \epsilon_1 z_5 + \epsilon_0 + u_2$$

In this system of equations z_5 which is range conditions in 17 western states on July 1 is used as the instrumental variable from the supply equation. This system of equations resulted in the following estimation equation:

$$y_2 = -.0017_{y_1} + 1.0033_{z_1} - 2.5524_{z_2} + .0105_{z_3} - 1.3508$$

This estimation equation differs from the other instrumental variable equation and also slightly from the limited information estimation equation. A non-economic factor such as range conditions which does not depend on current prices may nevertheless be a dominant factor in determining the current supply of feeder cattle. This perhaps accounts for the change encountered when using the z_5 variable instead of the z_4 variable.

The Z_5 instrumental variable does not agree with the theory proposed in regard to the effect of the price of hogs on the price of feeder cattle. This estimation method states that the price of feeder cattle and the price of hogs move in the same direction- a result that does not appear reasonable. The other variables agree with the theory proposed and the "limited information" method in signs and the coefficients are practically comparable as to the magnitude of the other parameters.

In using this "just identified" instrumental variable approach it is very hard to tell whether the estimation equation using Z_4 or Z_5 gives the best results. Using this method of estimation would result in choosing one or the other system as the basis for estimating the parameters. Thus can be seen the advantage of using the "limited information" approach when the system is over identified in order that the variables Z_4 and Z_5 may both be taken into consideration simultaneously.

The estimation equation that resulted from the "limited information" method lies somewhere between the results obtained when Z_4 and Z_5 are alternately used as instrumental variables in the "just identified" cases. The Z_5 instrumental variable appears to have the most influence on the final equation reached by the "limited information" approach. The instrumental variable method of estimation is not as efficient as the "limited information" method of estimation in the "over identified" system but it is much more efficient as an estimation tool than the single equation method which will be discussed later.

The "just identified" case is less complex in computation than the "limited information" approach but through this method a choice must be made of the instrumental variable that is to be used, while in the "limited information" approach this choice is automatically made by the system. The "instrumental variable" method like the "limited information" approach is desirable in the respect that a choice only has to be made as to whether variables are endogenous and exogenous and the variables that are declared endogenous are determined jointly. The "instrumental variable" method leads to unbiased and consistent estimates of the structural parameters, but these estimates are not asymptotically most efficient since a certain amount of information is ignored. This information in the over identified system that prevails in the models proposed in this section would have been used to decrease the sampling error and increase the efficiency of the estimate.

Single Equation Statistical Analysis

In most studies of methods of estimating economic relations the classical single equation method has either been the starting point or at least a basis for comparison. This mathematically simple and elegant method requires that among the variables that enter into a certain relation one is selected as the dependent variable with the remaining ones being called independent variables. When one considers the fact that a whole system of equations is required to describe how economic variables are determined, it can easily be demonstrated that there are logical inconsistencies, in many cases, in applying the single equation method to the estimation of parameters. The first difficulty encountered in using this method was in the choice of a dependent variable.

The first variable considered as a dependent variable was y_2, which resulted in the following single equation:

$$y_2 = \beta y_1 + \gamma_1 z_1 + \gamma_2 z_2 + \gamma_3 z_3 + \gamma_0 + u_1$$

In using y_2 as the dependent variable in the single equation the following estimation equation was obtained.

$$y_2 = -.0002y_1 + 1.0328z_1 - 2.2396z_2 - .0338z_3 - .2264$$

When compared to the "limited information" method it is found to be surprisingly comparable. All of the signs for the coefficients are the same but their magnitudes are somewhat different from the limited information method. When compared with limited information approach the single equation appears to under-emphasize the effect of the quantity imported upon the price of the feeder cattle and it appears to over-emphasize the importance of the price of hogs on the price of feeder cattle.

After using the single equation method with y_2 as the dependent variable it is necessary to set up a single equation with y_1 as the dependent variable which resulted in the following:

$$y_1 = \alpha y_2 + \gamma_1 z_1 + \gamma_2 z_2 + \gamma_3 z_3 + \gamma_0 + u_2$$

In order to get the estimation equation in comparable form of the equation with y_2 as the dependent variable, the resulting single equation was divided through by the coefficient of y_2. This resulted in the following estimation equation:

$$y_2 = -.0405y_1 + .1678z_1 - 5.5617z_2 + 1.2700z_3 + 43.464$$

When this equation is compared with the first single equation it verifies the statement made earlier as to the logical inconsistencies which exist in many cases when applying the single equation method. For the single equation method to have been logical and consistent both of the estimation equations should have resulted in coefficients with comparable signs and magnitudes. The other reasons for not choosing the single equation method were discussed at the beginning of this chapter and will not be repeated here. The single equation was only introduced as a basis of comparison with the simultaneous equation methods of estimation. From the varying results of the single equation method the reader may note the bias that may appear due to the choice of a dependent variable and also from the assumption that must be made for the single equation which states that there is perfect correlation between all the independent factors affecting demanders and suppliers.

It has been one of the purposes of this chapter to construct a sampling model that reflects in part the relation of economic variables. The assumption that is put forth in this chapter is that the formation of economic variables can best be described by a set of simultaneous equations.

SUMMARY AND CONCLUSIONS

It is desirable to provide tools of analysis suited for public economic policy and resource allocation by the firm or for other purposes that are as much as possible independent of the personal judgment of a particular investigator. The econometric models put forth in this study on factors affecting the demand of feeder cattle by the cattle feeding firm have been conceived in this scientific spirit because the models, when fully developed and properly used, should lead all investigators to the same conclusions independent of their personal judgments.

This study has dealt mainly with the different factors which affect the demand for feeder cattle by the cattle feeding firm in Iowa. It has isolated the factors which were found to be the most important and through the use of statistical techniques the magnitudes of their parameters have been estimated. The importance of cattle feeding in Iowa is generally overlooked because of its great importance as a corn and hog producer. The first chapter serves to give one an idea of the importance of Iowa in feeding cattle and also a description of the structure of the cattle feeding operation.

In order to evaluate the factors that affect the quantity of feeder cattle demanded by the firm, a deductive analysis of the cattle feeding firm was made. Through this deductive analysis models were constructed as to the behavior pattern of the entrepreneur in the cattle feeder market. Realizing both buyers and sellers of feeder cattle were firms it was necessary to set up a theory for both the cattle feeders and suppliers of feeder cattle within the framework of the theory of the firm.

Through the theory constructed for the cattle feeding and feeder cattle supplying firms it was possible to set up models which could be measured statistically. Recognizing the fact that a whole system of equations are required to describe how economic variables are determined it was seen that the simultaneous equation approach as an estimation method should be employed.

Through the theory developed the factors found to be the most relevant in determining the demand for feeder cattle were:

1. The price of the factor feeder cattle to the entrepreneur of the cattle feeding firm. This was represented in the study by the cost of all weights and grades of feeder steers at Kansas City.
2. The price the entrepreneur expected to receive for the finished product cattle, which was represented by the cost of all grades and weights of slaughter steers at Chicago.
3. The price of the factor corn to the entrepreneur engaged in cattle feeding. This was represented in the study by the price of number 3 yellow corn at Chicago.
4. The price of the competing enterprise hogs which the entrepreneur would receive. This was represented by the price of barrows and gilts at Chicago.

5. The number of cattle on farms and ranges of the 17 western range states which represents an important source of feeder cattle to Iowa.

6. The range conditions prevailing on July 1st in seventeen western range states.

A statistical model was then constructed to estimate the importance of these variables on the number of feeder cattle purchased by the cattle feeders in Iowa. This was accomplished by the use of three different estimation methods which are:

(1) The "limited information" approach used with an "over identified" system of equations.

(2) The "just identified" instrumental variable method using only one instrumental variable from the supply equation at a time.

(3) The single equation method using only the variables from the demand equation.

The "limited information" and "instrumental variable" methods were used to provide the tools whereby the influence of the supply on the feeder cattle demanded might be estimated.

The price of corn was found to be the most important factor in determining the price of feeder cattle and finally the number of feeder cattle demanded by the firm. The price of finished cattle was found to rank second in importance as to the price entrepreneurs were willing to pay for feeder cattle and the number they would demand. The price of feeder cattle tends to follow quite closely the price of finished cattle and within the range of the data analyzed appeared to have little influence on the number imported for feeding.

The price of hogs was found to have a slightly negative influence on the price of feeder cattle and the number of feeder cattle demanded for feeding. The factors utilized from the supply equations appear to have a marked influence on the price of feeder and finished cattle and thus on the number that is demanded by the cattle feeding firm.

Much careful research both in the theory of the cattle feeding firm and the statistics involved is yet to be carried out, before one can draw a final, practical conclusion from the results obtained.

This study has served two important functions: (1) to indicate the relative importance of certain factors which condition the demand for feeder cattle by the cattle feeding firm, and (2) to discuss the part played by econometric models in determining the statistical techniques employed by the research worker. This study shows the results when economic theory and statistics are wed.

LITERATURE CITED

Anderson, T.W. and Rubin, Herman. "Estimation of the Parameters of a Single Equation in a Complete System of Stochastic Equations". The Annals of Mathematical Statistics Vol. 20 pp. 46-63. 1949.

Boulding, K.E. "Economic Analysis". Harper & Brothers, New York. 1948. pp. 421-436.

Cooper, Gershon. "The Role of Econometric Models in Economic Theory". Journal of Farm Economics. Vol. 30. pp. 101-116. 1948.

Girschick, M.A. and Haavelmo, Trygve. "Statistical Analysis of the Demand for Food: Examples of Simultaneous Estimation of Structural Equations." Econometrica, Vol. 15. pp. 79-110. 1947.

Haavelmo, Trygve. "Quantitative Research in Agricultural Economics: The Interdependence Between Agriculture and the National Economy". Journal of Farm Economics. Vol. 29. pp. 910-924. 1947.

____________. "Methods of Measuring the Marginal Propensity to Consume". Journal of American Statistical Association. Vol. 42. pp. 105-122. 1947.

Hart, A.G. "Anticipatious Business Planning and the Cycle". Quarterly Journal of Economics. Vol. 51. pp. 6-15. 1937.

Hennery, H.J. "Factors Influencing the Time of Buying Feeder Steers and Selling Them as Choice Summer Fed Steers. Kansas Experiment Station Bulletin 258. pp. 21-22. 1932.

Hicks, J.R. "Value and Capital". Oxford, The Clarendon Press. 1939. pp. 11-140.

Hopkins, J.A., Jr. "Economic History of the Production of Beef Cattle in Iowa." Iowa City, Iowa - State Historical Society of Iowa. 1928.

____________. "A Statistical Study of the Prices and Production of Beef Cattle." Iowa Agricultural Experiment Station Research Bulletin 101. Ames, Iowa. Dec. 1926.

Iowa Department of Agriculture. "Iowa Agriculture - Livestock, Poultry and Dairy". Bulletin 92.4. pp. 14-16. 1945.

Kaldor, N. "The Equilibrium of the Firm". Economic Journal, Vol. 44. pp. 60-67. 1934.

Knight, F.H. "Risk, Uncertainty and Profit." Houghton Mifflin Company. 1921. pp. 51-176.

Koopmans, Tjalling. "Statistical Estimations of Simultaneous Economic Relations." Journal of American Statistical Association. Vol. 40. pp. 448-466. 1945.

Mosak, J.L. "Interrelations of Productive Price and Derived Demand." Journal of Political Economy. Vol. 46. pp. 761-87. 1938.

Reder, M.W. "Studies in Theory of Welfare Economics." Columbia University Press. 1948. pp. 103-128.

Schultz, T.W. "The Theory of Firm and Farm Management Research." Journal of Farm Economics. Vol. 21. pp. 570-586. 1939.

Shepherd, G.S. "Agricultural Price Analysis". Ames, Iowa, Iowa State College Press. 1941. pp. 43.

Thomsen, F.L. "Agricultural Prices". New York and London, McGraw-Hill Book Co., Inc. 1936. pp. 368.

Tintner, G. "Theory of Production Under Non Static Conditions". Journal of Political Economy Vol. 50. pp. 675-67. 1942.

U.S. Department of Agriculture. Some Essentials in Beef Production. Bulletin 71. p. 20. 1943.

U.S. Bureau of Agricultural Economics. "Agricultural Outlook Charts". p. 16. 1940.

U.S. Bureau of Agricultural Economics. "Meat Animals, Farm Production and Income". 1947-1948. pp. 8.

U.S. Bureau of Agricultural Economics."Livestock and Meat Situation." Nov. 1948. also March 1949.

U.S. Production and Marketing Administration. "Livestock Market News Statistics and Related Data." 1938-1947.

U.S. Bureau of Agricultural Economics. "Meat Animals, Farm Products and Income." 1924-1945. pp. 24.

U.S. Bureau of Agricultural Economics. "Western Livestock and Range Report (17 Western States)." Monthly 1938-1947.

ACKNOWLEDGMENT

The author is deeply indebted to Dr. Sam H. Thompson for his many suggestions and constructive criticisms in the planning and completion of the study. The author is also deeply grateful to Dr. Leonid Hurwicz for his assistance and personal guidance throughout the study. Without the aid of Dr. Hurwicz it would have been impossible to have completed the statistical analysis which was attempted. Appreciation must also be expressed to Professor Frank Robotka, and Professor C.C. Culbertson for reading the manuscript and for their constructive suggestions.

Appreciation is extended to the Statistical Laboratory for the numberless computations which they did very efficiently.

Thanks are also due to my fellow graduate students for their valid criticisms and suggestions offered in regard to the study.